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Automated Repair Service Bureau:

Two Examples of Human Performance Analysis and Design in Planning the ARSB

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Two case studies are described in which human performance methodologies were applied during the development of the Automated Repair Service Bureau (ARSB). The first case study illustrates some of the human performance analysis and design conducted during the specification of the computerized work station that would replace the local test desk in Repair Service Bureaus. The second case study shows how job quality considerations led to improvements in the job of the Repair Service Attendant who receives initial telephone trouble reports from customers. At the same time, a net savings in the time to process the troubles was achieved.

I. INTRODUCTION

This paper discusses some of the procedures and results of human performance design and analysis work carried out during the development of the Automated Repair Service Bureau (ARSB). It illustrates several ways that human performance analysis has benefited the design and operation of the ARSB. Two case studies are presented:

(*i*) Analysis and design for the computerized work station that replaces the local test desk for testing telephone lines in telephone repair bureaus.

(*ii*) Application of job enrichment techniques to the Repair Service Attendant's (RSA's) job in the ARSB.

II. PROCEDURES FOR HUMAN PERFORMANCE ANALYSIS AND DESIGN IN THE ARSB

2.1 Background: Use of the local test desk in the pre-ARSB environment

The local test desk is an electromechanical console characterized by

analog meter scales, toggle switches, electrical cords, and flashing buttons. Its basic testing modes of operation have been in use, virtually unchanged, for over forty years. It includes both testing and communication capabilities, and permits several telephone lines to be accessed simultaneously for testing.

In the pre-ARSB environment, skilled technicians called testers, working at the local test desks, perform tests on telephone lines to establish probable causes of trouble on a line. They work from paper trouble reports passed to them by repair clerks who receive customer complaints. Testers also assist craft persons in the field who call in, requesting tests on lines they are working on. The tester is the one who normally makes dispatch decisions and finally ensures that particular troubles are repaired. Telephone trouble reports requiring dispatching are routed from testers to dispatchers, who assign jobs to craft persons calling in upon completion of previous jobs.

Analytical skills, as well as interpersonal skills, are required for a person to be a successful tester. In addition, the tester has to be a good coordinator of the repair process. The tester is normally the one who is responsible for ensuring that a trouble is dealt with to the customer's satisfaction.

In the first phase of the introduction of Mechanized Loop Testing (MLT), the number of testers required at a repair bureau was reduced. The content of the tester's job tended to shift towards those tasks which MLT was not designed to do conveniently, such as testing interactively with craft persons in the field. The tester, when provided with a Video Display Terminal (VDT) giving MLT tests, often continued to use the local test desk as before.

The first phase of MLT was not designed to replace the local test desk entirely. This is principally because of the highly interactive nature of the tester's job and the power and flexibility of the local test desk in providing a variety of specific tests suitable for troubleshooting more complex telephone problems.

The systems engineering requirement to replace the local test desk with a VDT interface and appropriate communications capabilities came during the second stage of the implementation of the ARSB. This required that all testing be carried out under computer control.

2.2 Definition of the problem

When replacing one testing system with another, the general requirement is to ensure that the new system permits the functional capabilities appropriate to the new work environment. The human performsnce design goal is to help specify the user interface to tbe new system and to ensure that the tasks associated with the new system are suited to the abilities and needs of the users of the new system.

The MLT system specification required that we design a VDT interface that, together with a proper communications set, would be the functional equivalent of the local test desk. That is, the new work position would provide the testing and communications capabilities so that users could perform the functions that were previously performed at the local test desk. Of course, the absence of the local test desk, and the presence of a set of tests at the VDT that provides the equivalent or better testing capabilities, will permit operating companies to structure the processing of trouble reports in a more flexible way than is currently possible with the presence of the local test desk.

2.3 Rationale for analyzing tha previous system

While the testing and communications features of the local test desk are known, we needed to know the way these features were applied in an operational environment, and which features were considered important or crucial by users. This knowledge would facilitate the transfer of testing capabilities to a VDT testing mode, and permit us to retain, where possible, the operational features considered to be the most advantageous.

We needed to understand fully what testers perceived to be the main advantages of the test desk. By this approach, we could attempt to incorporate as many as possible of these advantages into a VDT testing design. At the same time, we wished to make full use of the advantages of the VDT medium, as applied to testing areas.

2.4 Analysis of testing requirements

We decided to observe testers doing tbeir jobs in a normal operational environment. This observational study approach was chosen to assess what types of tests were actually done at a local test desk, and the conditions under which testing was done.

Over a period of several months, we closely observed testers' activities in three different operating companies by sitting with and talking to testers in their normal course of work activities. One of our early observations concerned the highly interactive nature of the tester's job. Much of a tester's time is spent communicating and coordinating repair activity among a variety of telephone company personnel. Actual testing of phone lines is only one of a large variety of tasks that testers carry out.

It became clear that the design of the local test desk replacement would have to facilitate both the testing and the communications portions of the tester's job. Neither portion could be neglected. The interactive nature of the tester's job often requires the tester to work on several problems in parallel. A tester can be working on a problem with one craft person when a second craft person calls in requesting

assistance. If the second request can be dealt with quickly, the tester may take care of it, then return to assisting the first craft person. Otherwise, the second craft person, as well as subsequent callers, will be temporarily placed on hold until the tester has finished working on the earlier problems.

We observed a high degree of interaction between the tasks of testing and communicating. Testers often would be testing a line at the same time they were talking with the person who needed the test. We also observed some of the work pressures confronting testers on their jobs. Pressures could be caused by work load, ambiguities in the analysis of telephone troubles and deciding what actions to take, and delays caused by waiting to talk to otber telephone company personnel. Also, working simultaneously on several troubles or having several other craft persons waiting on bold can further add to work pressures. We came to appreciate why one tester characterized his job as "fighting the test desk," although this characterization was mainly because of the pressures of interpersonal interactions, decision making, and time limitations rather than because of problems with the test desk itself.

2.5 Results and implications of observational study— guidelines for design

The preceding analysis of the tester's job yielded a set of design guidelines that will be used in creating a new work position and a new job category. The new job title will be Maintenance Administrator or MA.

The MA should be able to use the system flexibly for requesting interactive testing with craft persons and customers. Interactive testing requires that a craft person or customer participate in some way while a line is being tested. Voice contact between the MA and the craft person or customer is present during the interaction, usually both before and after testing the line. The system should as much as possible facilitate this interactive testing process so that it proceeds smoothly and efficiently. We decided that the required system for interactive testing would have the following characteristics:

(*i*) Required tests can be requested easily by the MA.

(*ii*) Appropriate communications and conference capabilities will be available.

(*iii*) The system will permit the request for interactive tests by MAs with craft persons or customers in as close to a "real time" mode as possible, i.e., interactive testing will not be held up unduly while waiting for test results from the system.

(*iv*) Talking and testing over the same line will be possible in a way that facilitates interactive testing.

(*v*) Several lines can remain accessed simultaneously and be sta-

tused appropriately so that the MA can conveniently work with several craft persons requiring intermittent assistance.

(*vi*) It will be possible to conveniently check detailed records for a line that is being tested.

(*vii*) The system will supply certain relevant line record information when test results on a line are returned.

2.6 The design of the human interface for testing and communications

(*i*) *General features*—The preceding testing and communications requirements led, after many design and redesign efforts, to a human-computer interface tailored specifically to the needs of the MA for requesting the tests formerly done at the local test desk. The requests available to an MA consist of test and information requests that permit testing to occur in a timely fashion in the normal working environment. The VDT display, or mask (called the TV mask, for Trouble Verification), developed for this purpose permits the MA to request these tests in a convenient manner. The TV mask provides a sophisticated visual display terminal or VDT interface for testing, as well as initiating certain communications with craft persons and subscribers.

A status region of the mask indicates all lines that are currently accessed by the system. For maximum flexibility, tests can be requested on any of the lines accessed. Up to five lines can be accessed at the same time so that, for example, tone may be placed on several lines, while the MA is working on another line. If the MA switches to another mask containing records, the original TV mask with all status information is stored and returned to the MA on request.

The communications console associated with the VDT will provide the MA with the necessary features for communications needs. Such features include conferencing capability, speed dialing of commonly used numbers, and appropriate sizing and arrangement of incoming and outgoing lines.

The VDT and communications console can be used in an integrated manner to allow the MA to talk and then request tests over the same telephone line, without having to drop and then reaccess the line. When the MA enters a telephone number on the TV mask and requests a talk line, the test system accesses the designated line for testing, and calls back the MA at the MA's work position over the communications console. When the MA answers the phone, the test system connects the MA's line to the line to be tested. The MA can then talk over the line, for example, to a customer or a craft person in the field, and then run tests on the line from the TV mask. When each test ends, the talk path is automatically restored so conversation can continue. This talking and testing path greatly facilitates the MA's job, which requires

a high degree of verbal interaction integrated with testing of phone lines.

(*ii*) *Specific examples of VDT test capabilities*—Here are three examples where an orientation towards the MA's needs and preferences resulted in appropriate testing capabilities being specified and implemented. All of these tests take into account the need for rapid system responses required for interactive testing with outside craft persons.

(a) *Tone*—Often a tester in a telephone repair bureau puts a tone on a pair to enable a craft person to find the pair by using a variety of tone detecting apparatus. When the craft person finds the pair, often the craft person wishes to signal the tester for assistance witb testing tbe line. Here is how this is accomplished with the new system.

A craft person calls tbe MA requesting a tone on a certain telephone number to locate the pair of wires associated with that telephone number. The MA will type in the telephone number on the TV mask displayed on the VDT screen. The MA then types in TONE in a request field. The MA can then go on to testing other telephone lines, while tone is supplied to the requested telephone number.

When the craft person finds the telephone line with the tone on it and shorts that pair of wires, the MA's screen will signal this by a beep and brighten the status line on the screen corresponding to the appropriate telephone number. The MA can then request T (for Talk) on that telephone number. The tone will then be dropped automatically and one of the MA's phones will ring, providing the MA with a talking path over that telephone line to the craft person in the field. Further testing and talking over that telephone line can then proceed by the MA's entering appropriate test and communication requests from the TV mask.

(b) *Pair identification*—Often a craft person will identify a pair of telephone wires in the field by placing an electrical sbort or ground on the pair and asking a tester, wbo is accessed to a specific pair, if the tester "sees" the short or ground by an immediate deflection of the needle on tbe tester's electrical meter. The craft person may try to locate a particular telephone pair by shorting or grounding a number of neighboring pairs often in rapid succession. To permit this pair identification capability from a VDT, the ARSB system was designed to measure and report a shorted or grounded telephone pair in a "real time" mode, i.e., without the several-second delay required for a result to be reported from the remote test equipment to the VDT screen.

To get into this "look for short" mode, the MA enters a telephone number and requests the command S (for short) at the TV mask. This sets the test equipment in a continuous measuring mode for detecting a short or ground placed on a line by a craft person. At the same time, the system calls one of the MA's telephones, providing a direct connection between the remote test equipment and the MA.

As soon as the craft person places a short or ground on the pair corresponding to the entered telephone number, the remote test equipment detects it and sends a tone back to the MA over the telephone line. The MA, who is in voice contact with the craft person over another line, can then immediately tell the craft person that the correct pair has been contacted. In fact, the MA may direct that the system call back the craft person directly to provide tone information that indicates when the craft person has shorted the pair. The tone remains on until the craft person removes the short or ground that was applied, and reappears if the short or ground is reapplied. By design, the tone is not sent back to the MA for a preexisting short or ground on the line. Only a change of conductivity corresponding to the application of a short or ground by a craft person is signaled.

This "look for short" mode will be very useful for interactive testing with outside craft persons, where rapid response times are highly desirable. Without human performance design input at an early stage in the project, this useful capability would certainly not have been implemented in its present form. The capability required that specific changes be incorporated into the system design. These changes would have been more costly to introduce into the design at a later stage.

(c) *Quick single-ended test series*—Another way was found to meet the MA's need for rapid test results when interacting with outside craft people. A stripped-down version of the previously implemented full test sequence was designed. The full sequence is carried out on a line to characterize the full extent of problems on the line, and to compare observed results with stored records. We determined that much of this detailed information is not always necessary or relevant during interactive work with outside craft people. The new QUICK test that resulted is expected to reduce the time to get useful test results by a factor of four or so, to about 5 seconds as compared to about 20 seconds for the complete test sequence.

2.7 Summary

In the full ARSB environment, a new computerized work station will replace the local test desk. A variety of tests and information requests will be carried out by an MA from a VDT, with a communications terminal being used as appropriate to facilitate the testing and coordination process. The MA will also provide assistance to craft persons who call in with requests for tests or information on lines they are working on in the field.

2.8 Conclusion

In conclusion, the application of human performance approaches

during the ARSB system design stage yielded significant benefits. It provided the opportunity for human performance designers to contribute to an ultimate system design that would be efficient and effective from the final user's point of view.

Section III illustrates another area where human performance design considerations had an important effect on job design and job quality in the ARSB.

III. JOB ENRICHMENT IN THE CENTRALIZED REPAIR SERVICE ANSWERING BUREAU

With the implementation of Loop Maintenance Operations System (LMOS) in ARSBs, the job of the RSA was removed from individual Repair Service Bureaus (RSBs) and placed in Centralized Repair Service Answering Bureaus (CRSABs). Each CRSAB serves several RSBs. Centralizing the RSAs takes advantage of the efficiencies possible from combining several smaller work forces that perform the same function into a single larger unit.

The RSA is the initial telephone company contact when a customer calls to report a telephone service problem. The RSA works at a VDT and operates a keyboard, which is connected to a computer. A customer calling to report a telephone problem is automatically connected to an RSA. The RSA obtains the customer's phone number, and enters it into a "Trouble Entry" mask on the VDT. The computer responds by displaying on the terminal a Trouble Report mask. This mask provides the customer's name, the address for that particular phone number, and the date of the last trouble cleared.

The RSA verifies the name and address, asks the customer to describe the trouble, enters the trouble description into the Trouble Report mask, and determines whether the trouble requires a repair visit to the customer's premises. If a repair visit is needed, the RSA makes an appointment with the customer and gives a time of day commitment for repair of the trouble. When the customer hangs up, the RSA transmits the trouble report to the computer.

The computer forwards the trouble report to the RSB, where a printout is made available. The computer updates its history files and presents a new Trouble Entry mask so that the RSA is ready to answer the next customer's call.

3.1 The problem

One consequence of centralizing the RSAs that was not fully anticipated was the effect on the RSA's job. In the decentralized environment, the RSAs frequently had the necessity and opportunity to discuss trouble reports with other employees. They also had the opportunity to do a variety of tasks (fill work) when the number of trouble calls

was low. In the CRSAB environment, the RSA's job does not normally require them to converse with other employees and the work is more repetitive with less variety. For example, a busy day may require an RSA to handle up to 270 calls—one every 100 seconds.

A survey of RSA attitudes regarding their jobs in the centralized environment indicated dissatisfaction with the repetition and lack of variety.[1] Another key area of concern was their lack of decision-making authority. Further study of the RSA job in the centralized environment led to the hypothesis that the quality of the job could be improved.

3.2 Approach to a solution

The purpose of the present study was to determine if the quality of the RSA job could be improved, while preserving the efficiencies provided by centralization. The approach taken was to apply one of the principles of job enrichment and try it out in a CRSAB. These principles indicate that a job designed to maximize interest, challenge, and satisfaction for an employee must do three things:

(*i*) Allow the worker to do a *complete* piece of work for an *identifiable* client.

(*ii*) Give the worker a high degree of *control* and *decision-making authority* over how that complete piece of work is carried out.

(*iii*) Provide *direct feedback*—from the worker's clients and through the work itself—on how well the worker is doing the job.[2]

The trial discussed here focused on giving the RSAs more decision-making authority. This is not to imply that the other principles were well fulfilled in the RSA job, but only that they would be dealt with in later trials.

Increased decision-making authority in the RSA job was made possible by the development of the MLT, which automatically tests the customer's telephone line while the customer and the RSA are talking. The results of the test are then displayed on the RSA's display terminal.

Based on the information made available by the MLT—along with customer information—the RSA can make three important decisions during the customer contact:

(*i*) whether to obtain access to the customer's premises,

(*ii*) whether to attempt front end close-out of the trouble, that is, to get agreement from the customer that there is no longer a problem with the line, and

(*iii*) whether to suggest that the customer take the phone set to the Phone Center Store for replacement.

Each of these decisions is discussed below.

If the MLT indicates that the trouble is in tbe central office or in the cable, no access to the customer's premises is needed. The time that the RSA must spend talking with the customer can be shortened.

If the MLT results indicate the customer's line is OK and certain other conditions exist, there may be no need for the telephone company to take any action on the trouble report and the RSA can attempt a front end close-out. For example, a customer may try to use his phone before leaving for work in the morning and discover he has no dial tone. By the time he calls in from his place of work to report the trouble, the problem may have been corrected at the Central Office. When the service attendant uses the MLT, it will indicate TEST OK. The attendant can then tell the customer that the line checks OK, and indicate that no further action is required. If the customer agrees, the RSA can complete a front end close-out transaction that updates the computer but sends no trouble report to the RSB. This saves the RSB from handling and processing a trouble that is nonexistent.

The third type of decision also requires information from the customer. If, in describing the service problem, the customer indicates the trouble is with only one telephone set among several in tbe home, and if MLT shows that no other problem exists, then the RSA can ask the customer to take the suspected set to the Phone Center Store. If the customer accepts the suggestion, the attendant can use the front end close-out transaction to update the computer, but send no trouble report to the RSB. Again, the Bureau is spared the handling of a trouble report that actually requires no action on the Bureau's part.

3.3 Design of the trial

The trial included a sample from one CRSAB of six RSAs who used MLT results during their contact handling. The RSAs selected for tbe trial were considered to be "typical" attendants—not the best nor the worst. Three males and three females participated. Their ages ranged from 18 to 27 years and their experience ranged from 4 to 18 months. Following initial training, the six RSAs used the new procedures during a two-month period.[3]

3.4 Results of the trial

As the six trial RSAs used MLT results during contact handling, the impact on RSA performance and job attitude, impact on the RSB and reactions of customers were assessed.

(*i*) *RSA job performance and attitudes*—One prime RSA performance measure considered was the impact on holding time of using the MLT results during the contact. Holding time is defined as the interval starting when the RSA first receives the customer's call until the RSA transmits the Trouble Report mask for that trouble. Table I provides a summary of results.

The data indicate that, on the average, front end close-outs took about 35 seconds longer to handle than ordinary customer contacts.

Table I—Holding time for customer contacts

Type of Trouble	Number of Calls Monitored	Mean Holding Time (seconds)	Range of Holding Time (seconds)
Front end close-out troubles	41	145	62 to 274
Cable and Central Office troubles	61	77	38 to 238
Ordinary troubles	654	110	33 to 559
Total	756	109	33 to 559

The close-out transaction and the need for RSAs to call back some customers to obtain agreement to the close-out account for the extra time.

On the other hand, for contacts where the trouble was found to be in either the Central Office or in the cable, the average holding time was about 33 seconds less than would be required on an ordinary customer contact. This shorter holding time was because the RSA did not have to arrange access to the customer's premises.

The attitudes of the trial RSAs toward the use of MLT results in their contact handling were very favorable. When interviewed, the RSAs said they particularly liked the increased information that they could share with customers, the increased challenge of making more decisions, and the increased importance of their job in that they could save the RSB paperwork on front end close-outs.

(ii) Impact on the RSB—One impact that the new MLT procedures have on the RSB is measured in terms of the amount of trouble report processing saved. Every trouble that is closed out by an RSA means one less trouble to be processed by the Bureau. Data from the trial show that if a trouble closed out by the RSAs had been transmitted to the Bureau, it would have required an average of 129 seconds of handling by Bureau personnel. As noted earlier, the increase in average RSA holding time because of front end close-out was 35 seconds. Therefore, it seems that for an additional 35 seconds of RSA time, 129 seconds of RSB time can be saved. The data in Table II show that nearly 8 percent of the calls taken were candidates for front end close-out.

Table II also shows that more than half the customers who were

Table II—Frequency of use of MLT results by RSAs

Type of Contact	Number	Percentage
Front end close-out candidates:		
Accepted by customer	125	4.6
Refused by customer	88	3.2
Cable and Central Office troubles	272	10.1
Ordinary contacts	2212	82.1
Total	2697	100.0

offered a front end close-out accepted. Those who refused usually did so because they had checked their telephone recently—within the last hour—and felt there still was a legitimate problem, even though the RSA's test equipment indicated that the line was working.

Another impact the new MLT procedures might have had on the RSB would be to change the number of repeat calls made on troubles originally closed out by the RSAs. However, the data showed that for troubles closed out by RSAs during the trial, the repeat rate was the same as that for troubles of this type closed out by the RSB during the same time period.

(*iii*) *Reactions of customers*—To learn how customers reacted to the use of MLT results in their contact with an RSA, several hundred contacts were monitored. Customers always reacted favorably when told their telephone trouble was in the cable or Central Office and that access to their premises was not necessary. Similarly—but to a lesser degree—customers appeared to appreciate the RSA's informing them that the test equipment had identified a definite fault, even though that meant the customer had to arrange access to the premises.

To find out what customers thought of their telephone line being automatically tested during their contact with the RSA, a sample of 60 customers was surveyed by telephone. When asked about their reaction to the automatic testing, half gave positive reactions and half were neutral. None gave a negative response.

3.5 Conclusion from the trial

In conclusion, having RSAs use MLT results during customer contacts has far more benefits than costs. The benefits are savings in time for the RSB, improved customer relations, and a more satisfying job for the RSAs. The cost is the time required to train RSAs to use the new procedures.

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